



# Transesophageal Echocardiography During Cardiopulmonary Resuscitation Is Associated With Shorter Compression Pauses Compared With Transthoracic Echocardiography

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**Study objective:** Point-of-care ultrasonography provides diagnostic information in addition to visual pulse checks during cardiopulmonary resuscitation (CPR). The most commonly used modality, transthoracic echocardiography, has unfortunately been repeatedly associated with prolonged pauses in chest compressions, which correlate with worsened neurologic outcomes. Unlike transthoracic echocardiography, transesophageal echocardiography does not require cessation of compressions for adequate imaging and provides the diagnostic benefit of point-of-care ultrasonography. To assess a benefit of transesophageal echocardiography, we compare the duration of chest compression pauses between transesophageal echocardiography, transthoracic echocardiography, and manual pulse checks on video recordings of cardiac arrest resuscitations.

**Methods:** We analyzed 139 pulse check CPR pauses among 25 patients during cardiac arrest.

**Results:** Transesophageal echocardiography provided the shortest mean pulse check duration (9 seconds [95% confidence interval {CI} 5 to 12 seconds]). Mean pulse check duration with transthoracic echocardiography was 19 seconds (95% CI 16 to 22 seconds), and it was 11 seconds (95% CI 8 to 14 seconds) with manual checks. Intraclass correlation coefficient between abstractors for a portion of individual and average times was 0.99 and 0.99, respectively ( $P < .001$  for both).

**Conclusion:** Our study suggests that pulse check times with transesophageal echocardiography are shorter versus with transthoracic echocardiography for ED point-of-care ultrasonography during cardiac arrest resuscitations, and further emphasizes the need for careful attention to compression pause duration when using transthoracic echocardiography for point-of-care ultrasonography during ED cardiac arrest resuscitations. [Ann Emerg Med. 2019;73:610-616.]

Please see page 611 for the Editor's Capsule Summary of this article.

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## INTRODUCTION

The use of point-of-care ultrasonography as a diagnostic adjunct during in-hospital cardiopulmonary resuscitation (CPR) is increasing and is suggested in the most recent American Heart Association guidelines.<sup>1</sup> Commonly used by emergency physicians, point-of-care ultrasonography can identify reversible causes of arrest such as pulmonary embolism and pericardial effusions,<sup>2</sup> errors in pulse check and rhythm analysis,<sup>3</sup> and cardiac contractility, which itself has been shown to be the best predictor of survival in cases without a shockable rhythm.<sup>2</sup> Transthoracic echocardiography is the most common point-of-care ultrasonography modality during CPR, although it requires the halting of chest

compressions to obtain adequate imaging windows and can be complicated by factors such as an air-filled stomach and body habitus.

Recent studies have demonstrated transthoracic echocardiography point-of-care ultrasonography interferes with chest compression delivery, leading to significantly prolonged hands-off time compared with manual palpation alone.<sup>4,5</sup> This is important because CPR guidelines emphasize limiting the duration of pauses to less than 10 seconds because these lead to loss of coronary and cerebral perfusion.<sup>1,6,7</sup> Maximizing the ratio of chest compressions to pauses, known as the chest compression fraction, has been shown to result in decreased mortality.<sup>8</sup>

### Editor's Capsule Summary

#### *What is already known on this topic*

Bedside ultrasonography can be helpful to identify some reversible conditions in the setting of cardiac arrest, and transesophageal echocardiography can be used to assess real-time adequacy of chest compressions.

#### *What question this study addressed*

This retrospective case series of 25 patients addressed whether transesophageal echocardiography is associated with briefer pulse check interruptions of chest compressions compared with transthoracic echocardiography or no bedside ultrasonography during cardiac arrest resuscitation.

#### *What this study adds to our knowledge*

Transesophageal echocardiography is associated with briefer pauses during pulse checks than transthoracic echocardiography or no echocardiography.

#### *How this is relevant to clinical practice*

There is the unproven possibility that transesophageal echocardiography may benefit resuscitation of cardiac arrest because of briefer pulse checks' possibly leading to less neurologic compromise in cardiac arrest survivors.

In contrast to transthoracic echocardiography, transesophageal echocardiography as a point-of-care ultrasonography modality does not interfere with chest compressions and has been shown to provide adequate images in nearly all critically ill patients, conferring practice-changing information more frequently compared with transthoracic echocardiography.<sup>9</sup> At our institution, emergency department (ED) CPR may be performed with manual palpation pulse checks, with either transthoracic echocardiography or transesophageal echocardiography. Because the benefits of point-of-care ultrasonography during CPR can be obtained without pauses in compressions when transesophageal echocardiography is used, we sought to assess whether the use of transesophageal echocardiography resulted in decreased pause duration compared with transthoracic echocardiography or manual pulse checks.

We hypothesized that transesophageal echocardiography-guided pulse and rhythm checks

would be shorter, on average, than transthoracic echocardiography or manual pulse and rhythm checks.

## MATERIALS AND METHODS

We performed a retrospective analysis of video recordings obtained routinely for quality improvement purposes during CPR. The analysis and reporting of these data were approved by the institutional review board.

### Setting

The University of Utah ED is a Level I trauma center and tertiary care facility staffed by board-certified emergency medicine faculty and postgraduate years 1 to 3 emergency medicine residents, with an annual volume of approximately 50,000 patients. Motion-activated cameras record video and audio activity in all 4 of our resuscitation rooms. These videos are used for quality improvement and educational purposes in both trauma and medical resuscitations. Resuscitation attempts are typically staffed by an attending physician, 1 or 2 emergency medicine residents, 1 to 2 emergency nurses, and 1 to 2 paramedics or emergency medical technicians. All emergency physicians are trained and credentialed in the use of transthoracic echocardiography point-of-care ultrasonography, with a limited number of attending physicians additionally trained to use transesophageal echocardiography.

### Selection of Participants

Adult patients ( $\geq 18$  years) were included who experienced medical or traumatic cardiac arrest with CPR that was video captured between March 1, 2016, and May 25, 2017. These were consecutive cardiac arrests receiving active resuscitation for which video was available.

Two trained abstractors, blinded to the study hypothesis, reviewed the digital video recordings of all sequential available CPR attempts and recorded the timing and duration of all pauses in chest compressions until efforts were ceased because of either a return of spontaneous circulation or a declaration of death. Pauses were defined as the time from the last compression until the start of the next compression and were recorded with precision to 1 second. For all recorded pauses, abstractors documented any interventions concomitantly performed (such as attempts at intubation or arterial access), whether transesophageal echocardiography or transthoracic echocardiography was used at the pause, whether a pulse or rhythm check was performed, and whether a shock was delivered. Compressions were not paused for transesophageal echocardiography insertion. Any areas of uncertainty were

adjudicated by one of the principal investigators. Duplicative cross abstraction was performed in 10% of cases to determine the agreement between reviewers. Demographics and resuscitation details were abstracted from the electronic medical record and nursing flow sheets.

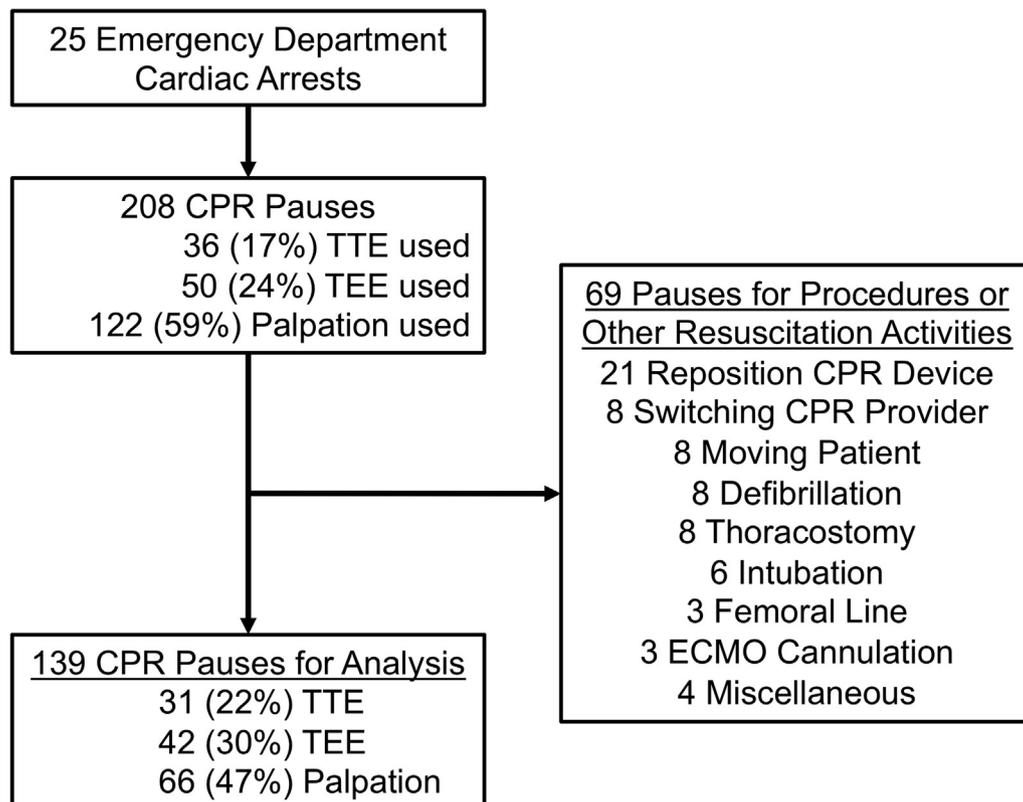
### Primary Data Analysis

All data were entered into an Excel spreadsheet (version 15.4; Microsoft, Redmond, WA) and analyzed with Stata (version 14.2; StataCorp, College Station, TX). To evaluate the independent effect of transesophageal echocardiography, transthoracic echocardiography, or manual palpation alone on the duration of CPR pause during pulse and rhythm checks, we compared the average duration of pause (primary outcome) associated with the 3 groups. We used generalized linear mixed models (mixed command in Stata), which accounted for variability both within and between patients for whom repeated measures were obtained. We excluded pauses during which procedures were performed. Because individual patients had multiple pulse checks with one or more modalities to assess for return of spontaneous circulation, we entered pulse check modality as both a random and fixed effect. Individual arrests were modeled as random effects. (In

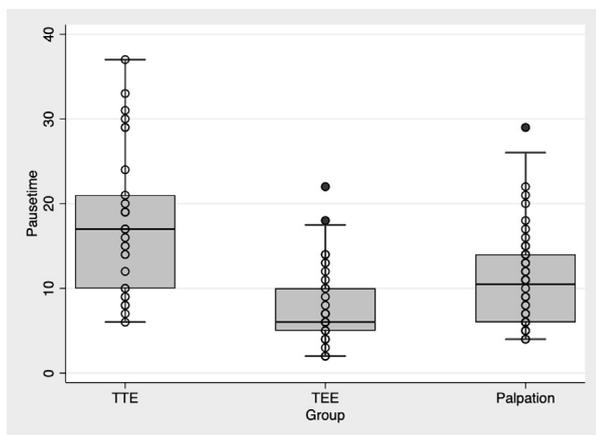
other words, individual pulse checks were nested within pulse check modality, which were nested within individual arrests.) We estimated that 31 pauses would provide 90% power to detect a difference in duration of pause of 5 seconds, with an  $\alpha$  of .05, assuming a correlation coefficient of 0.05 between measures and a common SD of 6 seconds. To assess agreement between reviewers, we calculated intraclass correlation coefficients on a portion of the data (27%; 31/139), using a 2-way random-effects model. We considered a  $P < .05$  to be statistically significant and all tests were 2 tailed.

### RESULTS

During the period between March 1, 2016, and May 25, 2017, there were a total of 25 arrests (23 medical, 2 traumatic), providing 208 pauses (139 CPR pauses for analysis and 69 pauses for procedures or other resuscitation activities). [Figure 1](#) shows demographic information, details the resuscitation attempts, and outlines the flow of patient data. Among all patients, 88% experienced an out-of-hospital arrest, whereas 12% arrested in the ED. Forty-eight percent were men, 32% (8/25) of arrests were witnessed, and 20% of patients (5/25) had bystander CPR. Sixteen percent of patients (4/25) had an initial shockable



**Figure 1.** Overview of total cardiac arrest pauses included for analysis. *TTE*, Transthoracic echocardiography; *TEE*, transesophageal echocardiography; *ECMO*, extra corporeal membrane oxygenation.



**Figure 2.** Bar graph of mean compression pause times comparing palpation alone, transthoracic echocardiography use, and transesophageal echocardiography use.

rhythm, 28% (7/25) had either asystole or pulseless electrical activity as an initial rhythm, and 56% (14/25) had an unknown initial rhythm, whereas 12% achieved out-of-hospital return of spontaneous circulation. In unadjusted analysis, transthoracic echocardiography was associated with an average pause duration of 18 seconds (SD 8 seconds), transesophageal echocardiography 7 seconds (SD 5 seconds), and manual palpation 10 seconds (SD 5 seconds).

Figure 2 provides point estimates of generalized linear model-adjusted mean pauses performed with transesophageal echocardiography, transthoracic echocardiography, or manual palpitation, with 95% confidence intervals (CIs). Figure 3 displays a dot plot of the individual pause times for each arrest. Arrests without pauses had time of death called on arrival. Resuscitations guided by transesophageal echocardiography were associated with a mean duration of pulse check of 9 seconds (95% CI 5 to 12 seconds), whereas resuscitations guided by transthoracic echocardiography were associated with a mean duration of pulse check of 19 seconds (95% CI 16 to 22 seconds). Resuscitations using manual pulse checks without ultrasonography were associated with a mean duration of 11 seconds (95% CI 8 to 14 seconds). The difference between transthoracic echocardiography and transesophageal echocardiography at 10 seconds provided a 95% CI of 5 to 14 seconds. The difference between transthoracic echocardiography and manual palpation at 8 seconds provided a 95% CI of 4 to 11 seconds. Finally, transesophageal echocardiography and manual palpation at -2 seconds provided a 95% CI of -6 to 2 seconds. Calculated intraclass correlation coefficients between individual and average

measurements were 0.99 and 0.99, respectively, suggesting high level of agreement.

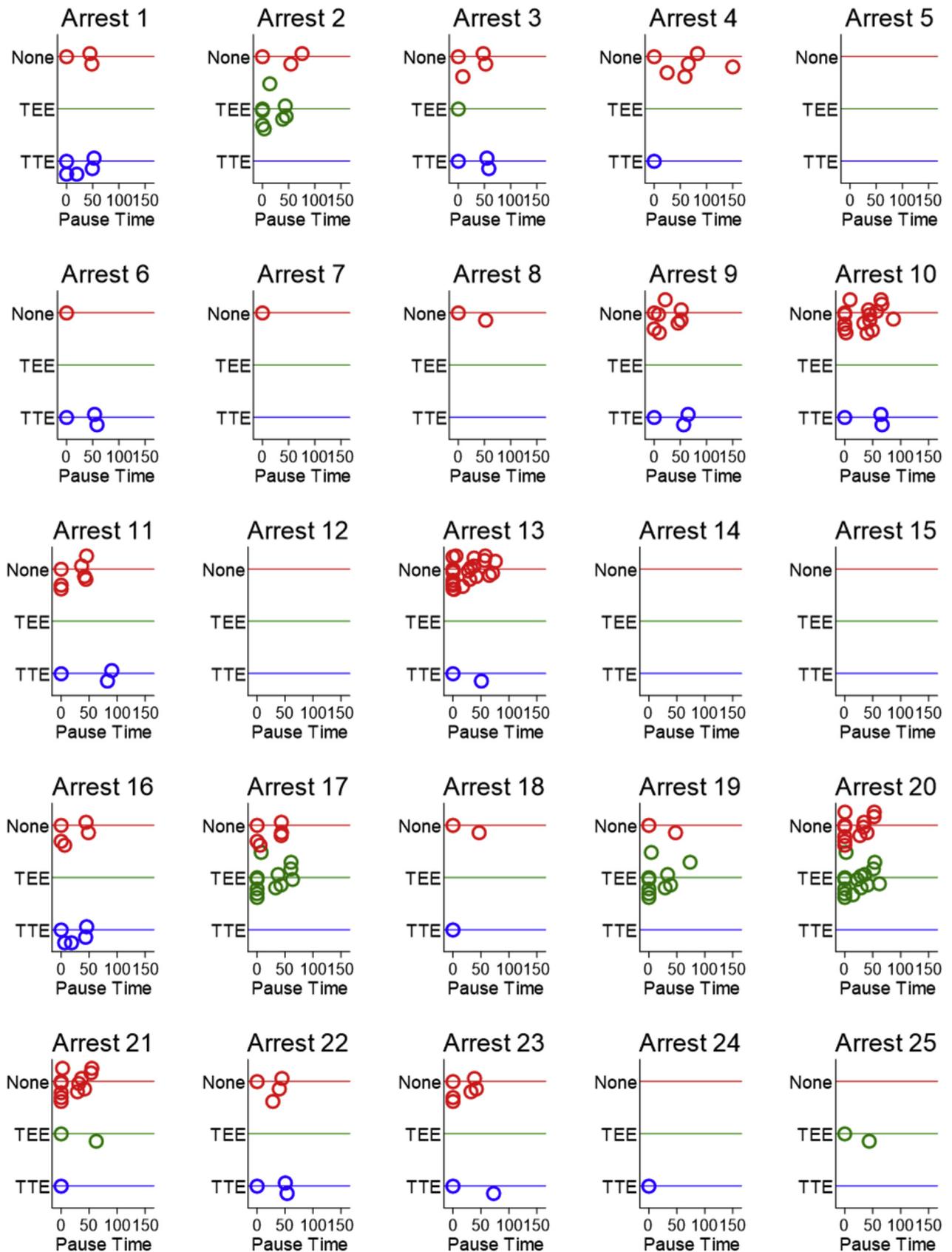
## LIMITATIONS

The primary limitation of this study was the retrospective nature, limiting the precision of the pulse check timing obtained from video review. A prospective study with independent time checks would enable more precision. The study was powered only to detect differences of 5 seconds, which may be inadequate to distinguish between manual checks and transesophageal echocardiography. During the period included in this study, there were only 4 attending emergency physicians at our institution who used transesophageal echocardiography in ED cardiac arrest resuscitations, and all 4 had ultrasonographic fellowship training, meaning that if transesophageal echocardiography was used, then an ultrasonographic fellowship-trained provider was present for the resuscitation. Although the provider performing the ultrasonography was not the one running the code, his or her involvement may have influenced compression pause duration. It is possible that a small number of arrests occurred during the study period for which video was not available because of technical failure, but we are not aware of any missed cases. Last, this was a single study from an academic center and is not necessarily generalizable to other practice environments.

## DISCUSSION

This retrospective analysis of compression pause times during ED CPR compared duration of pauses in compressions for pulse checks when transthoracic echocardiography, transesophageal echocardiography, or manual palpation alone was used. We found a statistically significant prolongation of compression pause times when transthoracic echocardiography was used compared with transesophageal echocardiography or manual pulse checks. Transesophageal echocardiography was similar to manual pulse checks in this study.

Our findings are similar to those of multiple recent studies that have found an association with transthoracic echocardiography use and longer CPR pauses. The 2 most recent publications demonstrated averages of 17 and 21 seconds with transthoracic echocardiography use, similar to our findings of an average of 19 seconds.<sup>4,5</sup> Although these studies did not examine patient-centered outcomes related to point-of-care ultrasonography use in cardiac arrest patients, prolonged pauses in chest compressions have been shown to lead to worse outcomes and should be avoided.<sup>10,11</sup>



**Figure 3.** Dot plot displaying individual pause times within each arrest.

Our findings are important in light of the potential conflict between the American Heart Association guidelines to maximize compression fraction during CPR and obtaining useful diagnostic information with point-of-care ultrasonography. We demonstrated that point-of-care ultrasonography using transesophageal echocardiography resulted a duration of pause similar to that of manual palpation alone, which was significantly shorter compared with that for point-of-care ultrasonography with transthoracic echocardiography.

The benefit of point-of-care ultrasonography during CPR includes its ability to correct misclassification of rhythm analysis, as well as identify reversible causes of cardiac arrest. As was demonstrated in the REASON study, point-of-care ultrasonography can successfully identify subsets of patients with pulseless electrical activity arrest with a better prognosis, such as those with evidence of right ventricular strain or pericardial tamponade.<sup>2</sup> Unfortunately, studies of point-of-care ultrasonography using transthoracic echocardiography have consistently demonstrated prolonged pauses in compressions. Transesophageal echocardiography provides a solution to this dilemma by offering continuous visualization of the heart during both compressions and pauses without interfering with chest compressions. Although not demonstrated in this study, transesophageal echocardiography has the potential to facilitate shorter compression pause times compared with manual pulse checks, and if cardiac standstill is clearly visualized during a pause in compressions, providers do not necessarily need to wait the full 10 seconds to determine the absence of a pulse.

In this retrospective analysis of pause duration during ED CPR, pauses during point-of-care ultrasonography with transesophageal echocardiography were significantly shorter than those using transthoracic echocardiography, and comparable to manual pulse check duration. Our findings suggest a potential benefit of transesophageal echocardiography for point-of-care ultrasonography compared with traditional transthoracic echocardiography, and additionally highlight the need for careful attention to pause duration when transthoracic echocardiography is used during CPR. Larger studies are necessary to investigate the potential effect of the choice of ultrasonography modality on patient-oriented outcomes.

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